METHOD AND APPARATUS FOR LOCALIZATION OF HAPTIC FEEDBACK

BACKGROUND

[0001] The present disclosure relates generally to methods and apparatus for providing haptic feedback, and more particularly relates to methods and apparatus for localizing of haptic feedback by limiting the effects of vibratory crosstalk between feedback positions.

[0002] The term "haptic" refers to touch or tactile sensation, and the term "haptic feedback system" refers to a system configured to provide a selective tactile feedback sensation (such as a vibration or other physical sensation, etc.) at a contact location of a surface in response to contact of a user at that location. Such haptic feedback systems include an input surface and one or more actuators (such as piezoelectric transducers, electromechanical devices, and/or other vibration inducing devices) that are mechanically connected to the back of the input surface. Drive electronics coupled to the one or more actuators cause the actuators to induce a selected vibratory response into the surface to which they are attached, thereby providing a tactile sensation to a user.

[0003] Many conventional devices, such as touch screen interfaces, have multiple feedback locations provided on a single surface, where typically each contact location will correspond to a user input location. With many such touch screen devices, a single actuator vibrates the entire surface relative to input at any one of several locations on the surface. Such devices offer essentially no localization of the haptic feedback. However, devices have been proposed where multiple actuators are distributed along the surface, each at a separate contact location, to provide some localization to the user feedback. However, because there are multiple actuator inputs into a single surface, the vibration can propagate to other locations, thus limiting the ultimate localization effect.

[0004] The problem of propagating tactile sensations from the selected input location to other locations across the input surface (sometimes referred to as "vibratory crosstalk" or "tactile crosstalk") can be especially pronounced in multi-touch systems, such as a virtual keyboard or keypad, a multi-touch track pad, or a touch screen interface, having multiple contact locations. In such systems, the number of actuators can be increased to improve the granularity of the tactile sensation; however, such systems typically still suffer from undesired vibratory crosstalk.

[0005] Accordingly, embodiments of haptic feedback systems and methods are disclosed below that provide new methods and apparatus providing improved localization of haptic feedback provided through an input surface.

SUMMARY

[0006] Haptic feedback methods and apparatus are disclosed that use a plurality of individually actuable actuators coupled to an input surface to induce vibrations into the surface, both to provide feedback vibratory response to a user, and also to assist in localizing that feedback vibratory response to the user input location. In response to a user selection at an input location, the system will generate a first feedback signal configured to provide a desired vibratory response to a user. The system will also induce vibrations at one or more other locations to suppress vibratory crosstalk resulting from at least the initial feedback signal. This suppression may range from changing the perceivable vibration response an another location to mask or otherwise obscuring the propagating vibratory crosstalk, to general cancellation (to at least some degree) of such vibratory crosstalk, such as through destructive interference. In some examples, the system includes a controller configured to activate a first actuator of the plurality of actuators to induce the described tactile feedback vibration at a selected contact location of the input surface, and further configured to activate one or more additional actuators to induce a suppression waveform vibration to assist in localizing the first vibration at the selected input location.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** depicts an example computing system including an input device of a type that can benefit from a haptic feedback system configured to suppress propagating vibrations, in one illustrative operating configuration.

[0008] FIG. **2** depicts a generic single surface input device, depicted in block diagram form, as may benefit from a haptic feedback system configured to suppress vibratory crosstalk.

[0009] FIG. **3** depicts a graph of waveform amplitude versus input location for a feedback vibration provided at a selected input location and a vibratory crosstalk suppressing waveform provided to an adjacent input location for the generic input device of FIG. **2**.

[0010] FIG. **4** depicts a haptic feedback system, illustrated in block diagram form, the system configured to suppress propagating waveforms, with the propagating waveform and suppression waveform superimposed over the contact locations.

[0011] FIG. **5** depicts a flow diagram of an example embodiment of a method of providing localized haptic feedback while suppressing vibratory crosstalk using a haptic feedback system.

DETAILED DESCRIPTION

[0012] The following detailed description refers to the accompanying drawings that depict various details of examples selected to show how particular embodiments may be implemented. The discussion herein addresses various examples of the inventive subject matter at least partially in reference to these drawings and describes the depicted embodiments in sufficient detail to enable those skilled in the art to practice the invention. Many other embodiments may be utilized for practicing the inventive subject matter than the illustrative examples discussed herein, and many structural and operational changes in addition to the alternatives specifically discussed herein may be made without departing from the scope of the inventive subject matter.

[0013] In this description, references to "one embodiment" or "an embodiment," or to "one example" or "an example" mean that the feature being referred to is, or may be, included in at least one embodiment or example of the invention. Separate references to "an embodiment" or "one embodiment" or to "one example" or "an example" in this description are not intended to necessarily refer to the same embodiment or example; however, neither are such embodiments mutually exclusive, unless so stated or as will be readily apparent to those of ordinary skill in the art having the benefit of this disclosure. Thus, the present invention includes a variety of combinations and/or integrations of the embodiments and examples described herein, as well as further embodiments